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S. V. GEBHARDS

EFFECTS OF FOREST INSECT SPRAYING
ON TROUT AND AQUATIC INSECTS
IN SOME MONTANA STREAMS

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Progress Report for 1956
Issued June 1957

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Helena, Montana

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INTRODUCTION

Dead fish were found in the Yellowstone River in the fall of 1955 in such numbers that considerable concern was felt by sportsmen, biologists, and administrators. In seeking an explanation for this apparently unusual mortality, some investigators related it to a July 1955 aerial application of DDT to widespread forest areas. This spray program was carried on by the U. S. Forest Service, the U. S. National Park Service and the Montana State Forest Department for the control of spruce budworm in Douglas-fir.

The Montana Fish and Game Department, the U. S. Fish and Wildlife Service, and the U. S. Forest Service, accordingly, organized a cooperative administrative study in 1956 to test the effects of actual spray operations on several Montana trout streams. Fish shocking to determine indices of fish populations and sampling of aquatic invertebrates to determine amount of fish food were carried on before and after spraying on thirteen streams. These streams were located in the Helena, Beaverhead, and Lewis & Clark National Forests in Montana. Two streams, Canyon and Trapper Creeks on the Beaverhead National Forest, were studied more intensively than the others.

Acknowledgements

The authors wish to thank James Posewitz for his work on the compilation of the fish shocking data and Daniel Block for his work on identification and compilation of the insect data. As foremen of the two field crews, Posewitz and Block contributed materially to the success of the project.

The illustrations are Forest Service photographs taken by Barry C. Park.

A selected list of references dealing with studies on DDT-fish relationships is included at the end of the report as a guide for workers interested in the results of other investigations.

SUMMARY AND CONCLUSIONS

This cooperative study was established to facilitate comprehensive research needed in conjunction with the use of DDT aerial sprays in western forest areas. The primary purpose of the interim administrative study was to obtain information as quickly as possible for immediate use in conjunction with the current spruce budworm control program. The immediate objective was to determine the effect of the aerial application of one pound of DDT per acre on the fish resources and ways of minimizing any possible detremental effect.

Considerable data were collected in the single season, but, because of the many variables and the difficulty of obtaining adequate samples, more data over a longer period of time are needed. There will be many important questions still unanswered even after another season's work. It will require several years of research work to gather sufficient data to determine the general long-term effects of DDT aerial spray on fish resources and to determine the best ways of minimizing the effect.

Fish shocking operations to determine indices of fish abundance and bottom sampling to determine the amounts of fish food were carried on prior to and following spraying on 13 mountain trout streams on 3 national forests in Montana where spraying was done in 1956.

Two streams, Canyon Creek and Trapper Creek, were studied more intensively than the others.

Summarization of the results is as follows:

1. There was no indication from the data collected during the period from June 22 to October 11, 1956 that trout were directly affected by the spray.

2. Aquatic bottom invertebrates and adult aquatic insects (aerial) were materially reduced by the DDT spray.

3. Trout gorged themselves on the immature and adult insects killed by the DDT during the 5-day period that these dead insects were being carried downstream, but no direct mortality of fish was observed.

4. Bottom samples taken in October showed partial repopulation of aquatic insects in sprayed sections which had suffered a decrease following spraying.

5. Rates of recovery of bottom fauna populations appear to be related to the amount of the stream headwaters left unsprayed.

6. The effect of the aerial DDT spray upon stream-bottom fauna decreased with the distance below the spray area. The fauna appeared to be normal 1½ miles below the spray area on Trapper Creek.

7. Trout in sprayed sections where the bottom fauna were depleted fed on terrestrial insects and fly larvae.

8. Chemical analysis of a water sample taken 27 hours after spraying showed no DDT.

9. Chemical analysis of a water sample taken after a 1.2 inches rainfall showed no leaching of DDT into the stream.

10. Hydrogen-ion concentrations and methyl orange alkalinity determination were found to be within ranges considered favorable for fish and aquatic insects.

The following suggestions are made to minimize the effect of DDT aerial spraying on fish resources:

1. Spray spruce budworm infestations before they reach upper drainage areas.

2. Undertake spruce budworm control programs before infestations cover large acreages of forest land.

3. Wherever practicable spray around the edge of lakes with small planes and when wind velocity is low.

4. Spray the forest along streams in such a manner as to avoid airplane turns over the streams.

5. Should mechanical difficulties be encountered on aircraft necessitating discharge of the spray load, make every effort to keep the spray away from streams or lakes.

It can be concluded that the aerial application of one pound of DDT per acre reduced immature and adult stages of aquatic insects in Canyon and Trapper Creeks. Trends toward insect repopulation in the streams were shown by bottom samples taken two months after spraying.

Observations indicated no direct kill of trout or any apparent change up to early fall. Possible delayed effects during the late fall and winter will not be known unless further work is done during the 1957 season.

METHODS

The general plan of the study featured two approaches to the matter of effects of DDT on stream animals. One part of the study, the intensive, was conducted on two streams only, and emphasized increased frequency of sampling, careful and precise observations, and daily measurements. The other part of the study, the extensive, was done over a wide area, the object being to secure measurements on a great variety of stream situations. This work was done on Prickly Pear, Trout, Beaver, Birch, Rock, Rattlesnake, Crow, McClellan, and Sheep Creeks and the north forks of Musselshell and Smith Rivers.

Trout Population Index and Condition

No attempt was made to determine the trout population of any streams, but only an index of the population before and after spraying. The electric-shock method was used to determine this index. It is the method employed by the Montana State Fish and Game Department to determine populations. Using a portable 500-watt alternating current generator producing 240 volts, each stream section of 300 feet was divided into two 150-foot sections except for a few sections where it was possible to block only as a 300-foot section. Sections were shocked repeatedly until a maximum recovery had been made. Voltage used was dependent upon stream conditions but it was kept as low as possible to avoid injury to fish. Stunned fish were picked up in a dip net and placed in wire net holding pens along with those taken in the end block nets. These fish were anaesthetized in a 0.5 percent solution of urethane before weighing and measuring. Lengths to the nearest tenth of an inch and weights to the nearest 0.01 of a pound were taken. The trout were allowed to recover before being released into the same section from which they were taken. (Figures 1, 2, 3, and 4.) All shocking was done between June 8 and August 16. The same sections in each stream were shocked before and after spraying and Canyon and Trapper Creeks were shocked a third time. It was planned to shock these two streams a fourth time in late October or early November. However, large quantities of water-soaked leaves on the stream bottom at this time prevented shocking because the leaves quickly choked block nets and they could not be held.

Condition factors from weight and length were determined for all trout taken as a further means of checking the effect from DDT spray. Condition factor expresses the condition, relative robustness, or "degree of well-being" of fishes. C, the condition factor, equals $\frac{100,000\ W}{L^3}$, where W equals the weight in pounds and L equals the standard length in inches.

The center of each shocking section was marked by a concrete block set in the ground, and an orange steel fence post was driven into the ground at each end of the sampling section.

DDT Spray

The spray consisted of one pound of DDT dissolved in 1.25 quarts of hydrocarbon solvent and diluted in sufficient fuel oil to make one gallon of insecticide. An airplane was used to disperse the spray over the forest during June and July, 1956 at the rate of one gallon per acre (one pound of DDT per acre). Varying amounts of spray reached the ground and water surfaces. A measurement of 0.20 pound per acre on the ground was necessary to obtain satisfactory spruce budworm mortality.

The average amount of DDT reaching stream-study sections was determined by placing oil-sensitive dye cards at 4-chain intervals on spray check lines running at right angles to the spray swath. On the two intensive study streams additional cards were placed along the edge of the stream in study sections. Seven cards were placed in each study section and one card on each of sixteen live cars, for a total of 93 additional cards.

Aquatic Invertebrates

A standard square-foot bottom sampler was used to make quantitive collections of invertebrates in the streams to determine the number and kind of organisms and the weight or volume per square foot at each collection station. (Figures 5 and 6.) Samples were taken before and after spraying. On the two streams studied intensively samples were taken six times during the period from June 22 to October 22. Five of these sampling periods were after spraying.

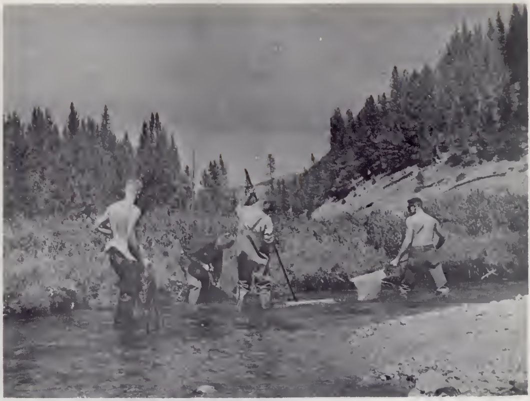

Figure 1. Fish shocking crew working station 2 on Canyon Creek.

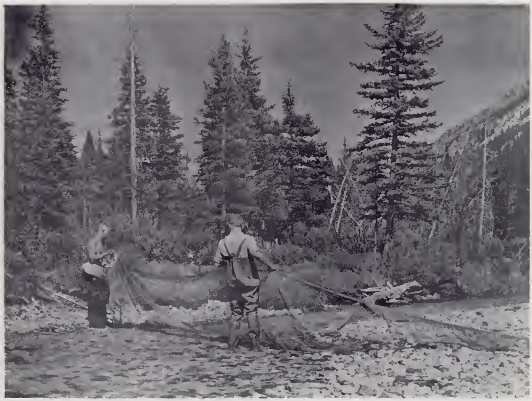

Figure 2. Installation of block net before starting shocking operations.

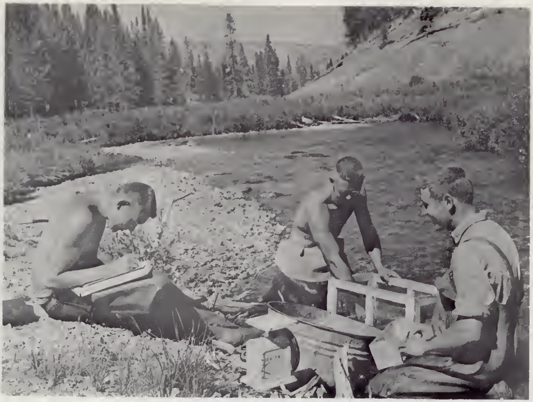

Figure 3. Weighing and measuring trout taken by shocking.

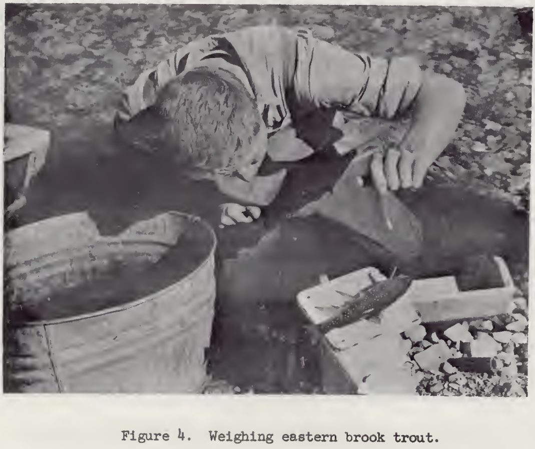

Figure 4. Weighing eastern brook trout.

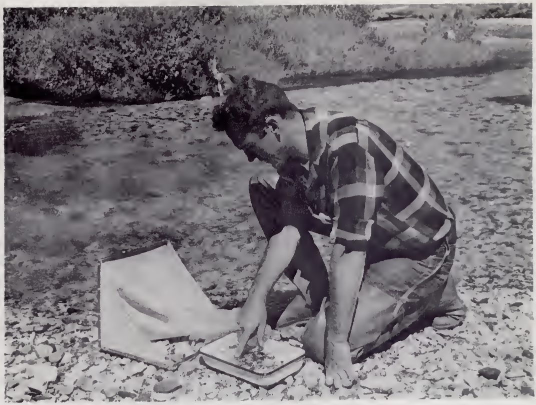

Figure 5. Square-foot bottom sampler with contents in enamel pan for segregation--Canyon Creek.

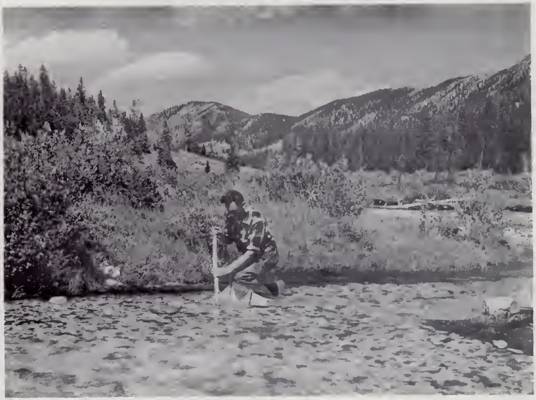

Figure 6. Taking a square-foot stream bottom sample.

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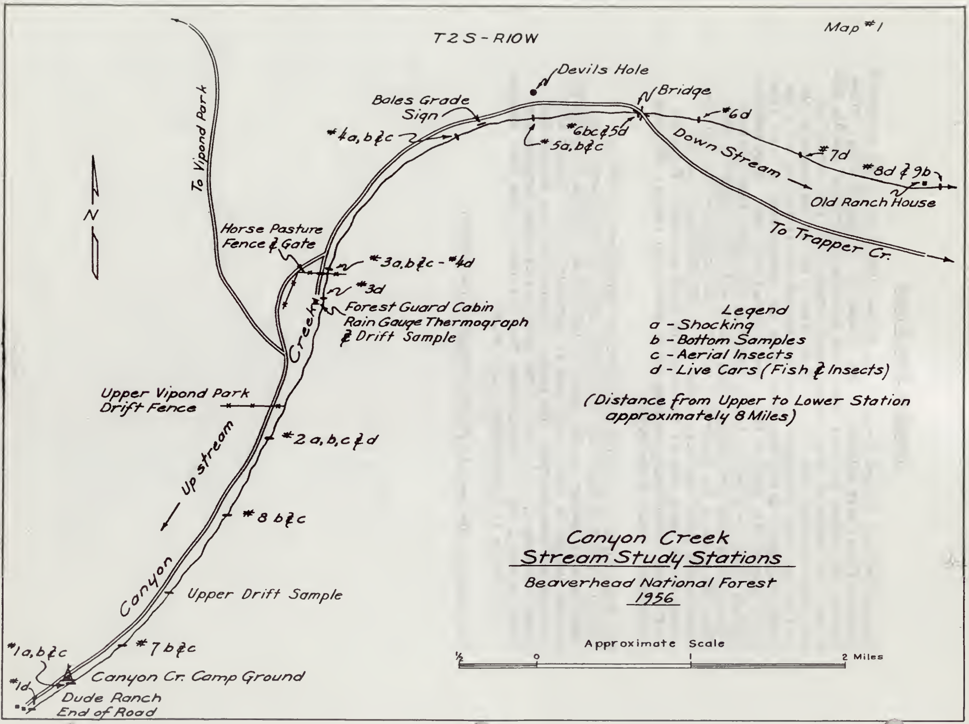
INTENSIVE STUDY STREAMS

Canyon Creek and Trapper Creek in the Pioneer Mountains on the Beaverhead National Forest were selected as the streams for intensive study. These streams are typical for this area, both being tributaries of the Big Hole River. The mouths of both streams are at about 5,100 feet elevations, with study sections from 6,000 to 8,000 feet. During the summer months most of the water in these streams is diverted for irrigation below the forest boundary. Within the study areas the streams vary in width from 10 to 25 feet with maximum depth from 6 inches to 8 feet. They meander through lodgepole pine and spruce timber in the upper study sections with an occasional open park; willow, birch and alder brush are found along the banks in the lower section. Fir and lodgepole pine join the brush on the south bank with timber 200 to 300 feet back from the stream on the north side of the stream or south exposure. Pools and riffles are intermittent; bottoms are of gravel and rubble. Sections of increased gradient are rocky.

The upper portion of each stream above the spray area was set up as a control. Stations were also established below the spray area. The sampling stations are not in numerical order from upstream to downstream because changes in spray plans made it necessary to add stations after the work had been started. The amount of spray reaching each station is shown in tables 1, 2, 6, and 7. The locations of study sections are shown on maps 1 and 2. The distance from the upper to the lower station on each stream is approximately eight miles.

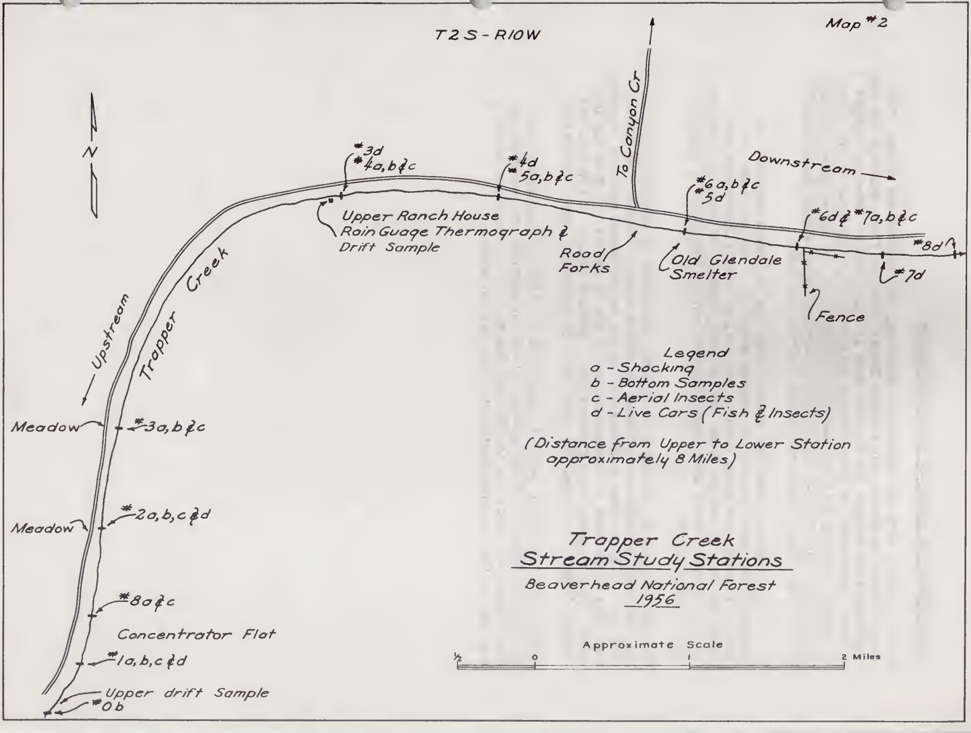
Both streams were heavily fished throughout the season.



Legend
a - Shocking
b - Bottom Samples
c - Aerial Insects
d - Live Cars (Fish & Insects)

(Distance from Upper to Lower Station approximately 8 Miles)

Canyon Creek
Stream Study Stations
Beaverhead National Forest
1956



Trapper Creek Stream Study Stations

Beaverhead National Forest 1956

Trout Population Index and Condition Factor

Tables 1 and 2 show the results of shocking, by stations and dates. The data obtained on Canyon and Trapper Creeks from the first shocking are not representative because the streams were in flood stage. Greater numbers of trout were taken on both streams following the spray than on the first shocking. Some of this increase was probably due to increased efficiency of the crew, but most of it was due to lowered water levels which made it possible to obtain a more efficient recovery of fish.

The trout in Canyon Creek had higher condition factors than those in Trapper Creek especially at the second shocking. Trapper Creek is heavily stocked with brook trout. Population index figures show the number of fish in Trapper Creek to be nearly double the number in Canyon Creek. Tables 6 and 7 show less volume of bottom organisms in Trapper than in Canyon Creek.

Fish were in poorer condition in Trapper Creek than in Canyon Creek. The information obtained, as shown on tables 1 and 2, shows this difference but the data taken before spraying and in unsprayed sections indicate that this difference in condition was not due to any effect from the DDT spray. Canyon Creek actually received a greater dosage of DDT than did Trapper Creek, 0.32 pound per acre and 0.19 pound per acre, respectively.

Shocking in the latter part of August did not indicate any reduction in trout populations on either stream. It will, however, be necessary to shock these same sections in July and August 1957 to determine if any loss due to DDT occurred during the late fall or winter.

Table 1 - Numbers of trout collected by shocking, Canyon Creek, 1956

Station No.	Spray reaching ground lbs. per acre	Species of fish1/	Before Spray June 15 - 16				After Spray July 13 - 16				After Spray August 13 - 14			
			No. fish	- Average - Length (inches)	- Average - Weight (lbs.)	Condition factor	No. fish	- Average - Length (inches)	- Average - Weight (lbs.)	Condition factor	No. fish	- Average - Length (inches)	- Average - Weight (lbs.)	Condition factor
							UNSPRAYED AREA							
1	0	CT	0				1	6.3	0.12	48.1				
1	0	EB	0				2	6.4	0.11	41.3	11	6.0	0.09	33.4
1	0	RBX	0								3	7.0	0.13	37.5
							SPRAYED AREA							
2	0.01	EB	4	5.7	0.09	33.7	17	6.2	0.12	42.3	18	6.4	0.11	35.9
2	0.01	RBX	2	5.2	0.06	38.1	7	6.4	0.12	34.7	7	6.2	0.09	33.7
3	0.32	CT	4	8.1	0.21	34.2	4	5.2	0.11	36.6				
3	0.32	EB	4	6.9	0.14	40.6	11	6.9	0.15	40.5	8	6.6	0.12	38.5
3	0.32	RBX	2	5.4	0.07	33.5	10	5.5	0.07	37.3	12	5.5	0.06	28.7
3	0.32	RB	3	6.0	0.09	30.3	2	4.9	0.05	40.6				
4	0.32	EB	3	5.3	0.05	31.1	20	5.3	0.07	36.2	22	5.0	0.05	37.1
4	0.32	RBX	4	7.6	0.15	30.3	2	6.0	0.09	36.8	3	6.2	0.09	33.4
5	0.32	EB	16	7.0	0.14	31.3	68	6.5	0.11	32.8	67	6.1	0.10	30.6
5	0.32	RBX					1	4.7	0.04	38.6	5	6.7	0.14	28.8
TOTAL			42				145				156			

Average condition before spray - 33.1 - first shocking
Average condition after spray - 38.8 - second shocking
Average condition after spray - 36.1 - third shocking

1/ CT = cutthroat trout
EB - eastern brook trout
RBX = rainbow x cutthroat hybrid
RB = rainbow trout

Table 2 - Numbers of trout collected by shocking, Trapper Creek, 1956

Station No.	Spray reaching ground lbs. per acre	Species of fish 1/	Before Spray June 16 - 17				After Spray July 16 - 17				After Spray August 15 -			
				- Average -				- Average -				- Average -		
			No. fish	Length (inches)	Weight (lbs.)	Condition factor	No. fish	Length (inches)	Weight (lbs.)	Condition factor	No. fish	Length (inches)	Weight (lbs.)	Condition factor
						UNSPRAYED AREA								
5	0	CT	0				1	4.4	0.02	23.3	0			
5	0	EB	23	5.5	0.06	30.6	52	5.5	0.08	34.9	37	5.9	0.09	34.8
5	0	RBX	1	4.9	0.04	33.9	0				0			
6	0	CT	0				1	9.1	0.32	42.7	0			
6	0	EB	19	6.3	0.09	30.5	24	6.1	0.09	39.9	13	5.9	0.10	34.9
6	0	BT	0				1	5.1	0.04	30.5	0			
						SPRAYED AREA								
1	.19	CT	1	6.2	0.08	33.2	11	6.7	0.11	34.6	6	5.8	0.09	36.8
1	.19	RBX	1	3.2	0.01	30.8	0				0			
1	.19	EB	1	7.3	0.12	30.8	5	6.5	0.12	37.6	9	6.4	0.12	41.7
2	.19	CT	0				3	7.2	0.12	31.5	9	5.4	0.06	33.4
2	.19	EB	5	5.4	0.05	31.1	46	5.3	0.06	34.8	82	5.3	0.06	35.7
3	.19	CT	2	4.7	0.04	34.0	4	7.0	0.12	33.9	13	6.2	0.10	40.6
3	.19	EB	9	4.5	0.03	26.5	62	4.8	0.04	32.8	63	5.2	0.06	35.7
4	.10	CT	0				0				4	7.3	0.14	32.3
4	.10	EB	28	5.3	0.06	30.5	47	5.6	0.08	35.4	78	5.7	0.07	32.5
4	.10	RBX	1	8.3	0.20	34.7	1	10.0	0.32	32.0	0			
TOTAL			91				258				314			

Average condition before spray - 31.8 - first shocking
Average condition after spray - 33.8 - second shocking
Average condition after spray - 35.6 - third shocking

1/ CT = cutthroat trout EB = eastern brook trout
RBX = rainbow x cutthroat hybrid BT = brown trout

Fish Live Cars

One hundred and sixty-two wild trout taken by shocking from the two streams were held in cages or live cars (8 in each stream) during spraying and for three days after spraying. (Figures 7 and 8 and tables 3 and 4.) The fish were collected and held 24 hours before placing in the individual cages to eliminate any loss from shocking and handling. The trout were placed in the cars 48 hours before spraying, for the same reason. Four fish were lost, two from the shocking and handling operation and two from damage from rocks in the cages. Curious fishermen apparently moved the cars, rolling the rocks and killing two trout. As the tables indicate, no fish were lost in the live cars on spray day or during the three days following spraying.

Some of the trout in live cars ate considerable amounts of the dead and dying insects that washed into the cages following spraying An abundance of these insects was available to the trout in all of the cars except those in unsprayed sections, but many of the fish opened had empty stomachs, indicating that the trout in live cars were not feeding. Free trout in both streams gorged themselves on these dead and dying insects. Some of the fish stomachs were so distended that insects could be identified through the stomach wall.

There was a noticeable difference between rainbow and eastern brook trout behavior in the cars. The brook trout were quieter and fed more consistently on the insects coming into the cars. At the end of the holding period all trout were in excellent physical condition but the brook trout were noticeably fatter.

Analysis of Trout Tissues

The analysis of trout tissue for DDT is shown in table 5. In general relatively low values were obtained in the tissues analyzed. It seems probable that DDT tends to accumulate primarily in the visceral fat, secondarily in the pyloric caeca and, occasionally in the kidney, probably during detoxification. The visceral fat was the most common location for DDT storage. DDT accumulation in this tissue varied from 0.01 microgram to approximately 4 micrograms per milligram of dry tissue.

The amounts of DDT were so variable in samples taken the same day and at the same station and throughout the season that no conclusions can be made.

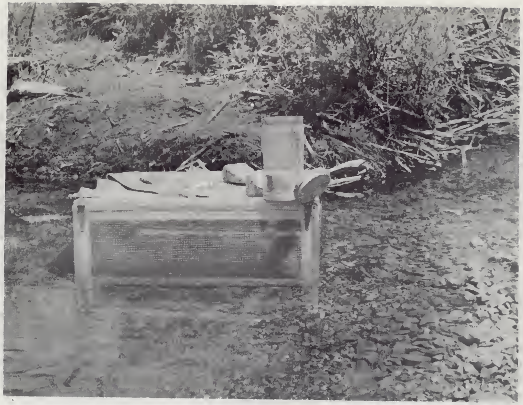


Figure 7. Fish and insect live cars.

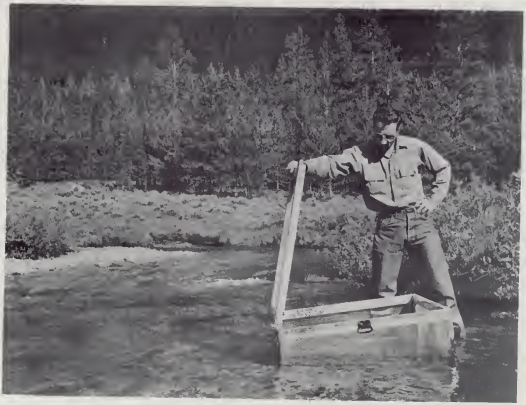


Figure 8. Fish live car at station 2--Canyon Creek.

Table 3 - Survival of trout in live cars, Canyon Creek, 1956

Live car number	Date & hour fish placed in cars	Species				Number of trout in car	Number of dead trout					
		E. Brook		Rainbow			Prespray		Spray day	Postspray		
		No.	size (inches)	No.	size (inches)		6/30	7/1	7/2	7/3	7/4	7/5 1/
1 Pool Dude Ranch	6/29 9:00 a.m.	1	8	1	10	10	0	0	0	0	0	0
		2	9	1	8							
		1	7	1	5							
		3	5									
2 Shocking station	6/29 8:30 a.m.	1	11	1	9	10	0	0	0	0	0	0
		2	10									
		1	8									
		2	7									
		1	6									
		2	5									
3 Canyon Creek cabin	6/29 8:00 a.m.	2	6	1	11	11	0	0	0	0	0	0
		1	5	2	10							
				2	8							
				3	7							
4 Camp area shocking station	6/29 9:30 a.m.	1	9	1	7	10	0	0	0	0	0	0
		1	8									
		1	7									
		1	4									
		5	3									
5 Pool at bridge	6/29 10:00 a.m.	1	8	1	9	10	0	0	0	0	0	0
		1	7									
		4	6									
		3	5									
6 200 yds. below bridge	6/29 10:15 a.m.	1	7	1	6	10	0	0	0	0	0	0
		2	6									
		4	5									
		2	4									
7 350 yds. below bridge	6/29 10:30 a.m.	2	8	1	6	10	0	0	0	0	0	0
		1	7									
		3	6									
		2	5									
		1	3									
8 Old corral and ranch house	6/29 11:00 a.m.	1	10	1	9	9	0	0	0	0	0	0
		1	9									
		1	6									
		1	5									
		1	4									
		3	3									
	TOTALS	63		17		80	0	0	0	0	0	0

1/ All fish removed from live cars on July 1 were in good condition.

Table 4 - Survival of trout in live cars, Trapper Creek, 1956

Live car number	Date & hour fish placed in cars	Species				Number of trout in car	Number of dead trout					
		E. Brook		Rainbow			Prespray		Spray day	Postspray		
		No.	size (inches)	No.	size (inches)		6/30	7/1	7/2	7/3	7/4	7/5 [1]
1 Shocking station	6/29 3:15 p.m.	3 2 4	5 4 3	1	4	10	0	0	0	0	0	0
2 Shocking station	6/29 3:00 p.m.	1 1 8	5 4 3			10	1 3-inch EB	0	0	0	0	0
3 upper farm	6/29 2:30 p.m.	1 3 1 3	6 5 4 3	1 1	5 4	10	0	0	0	0	0	0
4 Forks Rd. farm	6/29 2:15 p.m.	4 3	4 3	1 1	4 3	9	1[2]	0	0	0	0	0
5 Smelter	6/29 2:00 p.m.	2 7	4 3	2	3	11	0	0	0	0	0	0
6 above fence camp area	6/29 1:45 p.m.	1 1 1 7 1	6 5 4 3 2			11	0	0	0	0	0	0
7 corral & horse pasture	6/29 1:30 p.m.	2 5 2	5 4 3	1	4	10	0	0	0	0	0	0
8 lower road bridge	6/29 1:00 p.m.	1 1 8 1	5 4 3 2			11	0	1 3-inch EB	0	0	0	0
	TOTALS	74		8		82	2	1	0	0	0	0

[1] All fish removed from live cars on July 6 were in good condition.

[2] Killed by rock.

EB - Eastern Brook

Table 5 - Analysis of tissues from trout exposed to DDT, 1957[1/]

Stream & location	Date collected	Species & no.	Concentration of DDT - /ug. gm/ mg. dry tissues					
			Brain	Liver	Kidney	Pyloric caeca	Visceral fat	Whole fish homogenates
Trapper Cr. Station 3	7/4	3 EB	Trace	2/	2/	Trace	1.15	
Trapper Cr. Station 3	7/4	3 EB	2/	2/	2/	2/		
Trapper Cr. Station 3	7/4	1 EB	Trace	2/	2/	0.03	0.18	
Canyon Cr. Live Car 5	7/6	2 EB	2/	2/	0.34	2/	0.79	
Canyon Cr. Live Car 5	7/6	2 EB	2/	2/	Trace	0.04	Trace	
Canyon Cr. above cabin	8/16	1 EB 1 CT						0.01
Trapper Cr. Station 2	8/17	2 CT						2/
Trapper Cr. Station 2	8/17	2 EB	2/	2/	2/	2/		
Canyon Cr. Station 4	1-/20	1 CT	Trace	2/	2/	2/	4.0	

[1/] Chemical analysis made by the Willard, Washington Laboratory, U. S. Fish and Wildlife Service

[2/] No detectable amounts

EB = eastern brook trout
CT = cutthroat trout

Stream Bottom Samples

Square-foot bottom samples were taken throughout the season at nine stations on each stream with a Surber stream-bottom sampler (Surber, 1937). Five separate square-foot samples were taken at each station and the volume per square foot shown in tables 6 and 7 is the average of the 5 samples at each station. The data in these tables are, therefore, based on a series of samples taken on 6 different dates at each of 9 stations, and totaling 270 square feet for each stream, or a grand total of 540 square feet for both streams. Figure 5 shows equipment used, figure 6 the method of taking samples, and figure 9 the contents of a 1-square-foot sample from Canyon Creek.

The first bottom samples after spray day were not taken until most of the insects first affected by the spray had floated downstream. This date (July 6) was determined by drift sampling (tables 9 and 10).

Comparisons of volume of predominant animals before and after spraying on Canyon Creek and Trapper Creek indicate a material reduction in bottom organisms caused by the DDT aerial spray.

The last bottom samples were taken in October on both streams and, as shown in tables 6 and 7, there was a definite increase in volume of aquatic insects in the sprayed areas. However, by October, the average volume of samples taken at the sprayed stations on Canyon Creek (stations 3, 4, 5, and 6, table 6) averaged only one-fourth of the average volume before spraying. Samples from the unsprayed stations (1, 7, and 8) showed a fourfold increase during the same period. It is necessary to learn more about the rate of this recovery and the length of time required to reach a near normal aquatic bottom fauna population on both streams. This will require additional sampling during the 1957 season. The term "near normal" means the recovery of the predominant forms which produce the bulk of the food for trout in these streams.

Aquatic Insect Live Cars

Aquatic insect live cars were placed near each of the fish live cars before spraying (figure 7). Bottom fauna, predominantly immature stages of stone flies, may flies, and caddis flies were placed with stones in each live car. The effect of the DDT spray is shown in table 8. Mortalities agree with those from drift and square-foot bottom samples. Insects in the live car at the control station on Canyon Creek were unaffected. Insects in the live cars within the spray area were all affected and were dead or dying after 24 hours. The effect upon insects in live cars below the spray area decreased according to the distance below the spray area in Trapper Creek, appearing normal at 1½ miles and indicating that at this distance the amount of DDT in the water was so diluted that it did not affect the insects in the cages. This fact is further substantiated by the bottom samples taken at these stations (tables 6 and 7).

Table 6 - Volumes of stream insects collected in Canyon Creek, volume per square foot of predominant immature insects, 1956

Station	Spray (lbs. per acre)	June 22 Before Spray (cc.)	July 9 After Spray (cc.)	July 23 After Spray (cc.)	August 20 After Spray (cc.)	September 17 After Spray (cc.)	October 15 After Spray (cc.)	Totals (cc.)
1	0 Control	0.24 May flies	0.30 May flies	0.41 May flies	0.96 May flies & Stone flies	0.72 Caddis flies & Stone flies	0.70 May flies & Stone flies	3.33 3.09[1]
7	0 Control	0.34 May flies	0.45 May flies	0.42 May flies	0.56 May flies	0.43 Caddis flies & Stone flies	0.72 May flies & Stone flies	2.92 2.58[1]
8	0 Control	0.10 May flies	0.21 May flies	0.60 May flies	0.69 Caddis flies	1.26 May flies	2.22 Caddis flies & Stone flies	5.08 4.98[1]
2	0.01	0.34 May flies	0.36 May flies	0.63 May flies	0.94 Caddis flies	0.35 Caddis flies	0.82 Stone flies	3.44 3.10[1]
3	0.32 Average	0.64 Caddis flies	Trace Nematodes	0.08 May flies	0.06 May flies	0.03 Stone flies	0.32 Stone flies	1.13 0.49[1]
4	0.32 Average	0.70 Stone flies	0.01 May flies	0.03 May flies	0.01 Flies	0.01 Stone flies	0.20 Stone flies	0.96 0.26[1]
5	0.32 Average	0.79 May flies	0.04 May flies	0.02 Beetles	0.02 Flies	0.02 Stone flies	0.20 Stone flies	1.09 0.30[1]
6	0.32 Average	1.78 May flies & Caddis flies	0.07 May flies	0.01 Flies	0.16 Flies	0.09 Flies	0.18 Stone flies	2.29 0.51[1]
9[2]	Below Spray 1/8 mile	No sample taken	No sample taken	0.40 Flies Aug. 6	0.02 Flies	0.04 Stone flies	0.29 Stone flies	

[1] Total after spray.

[2] Station 9 same location as station 8 live car station. First sample taken in August.

Table 7 - Volumes of stream insects collected in Trapper Creek, volume per square foot of predominant immature insects, 1956

Station	Spray (lbs. per acre)	June 22 Before Spray (cc.)	July 11 After Spray (cc.)	July 25 After Spray (cc.)	August 22 After Spray (cc.)	September 19 After Spray (cc.)	October 22 After Spray (cc.)	Totals (cc.)
0[1]	None	no sample taken	0.08 May flies & Stone flies	0.10 May flies	0.10 May flies & Stone flies	0.31 Stone flies	0.46 May flies & Stone flies	1.05
1	0.19 Average	0.26 May flies	0.06 May flies	0.04 May flies	0.10 May flies	0.13 Stone flies	0.22 May flies & Stone flies	0.81 0.55[2]
8	0.19 Average	0.46 May flies	0.05 May flies	0.23 May flies	0.07 May flies	0.16 Stone flies	0.14 May flies & Stone flies	1.11 0.65[2]
2	0.19 Average	0.08 May flies	0.05 May flies	0.13 May flies	0.03 Flies	0.11 Stone flies	0.26 May flies & Stone flies	0.66 0.58[2]
3	0.19 Average	0.67 Stone flies	0.03 Stone flies	0.23 Flies	0.01 Flies	0.06 Stone flies	0.18 Stone flies	1.18 0.51[2]
4	0.10	0.52 May flies	0.10 May flies	0.18 May flies	0.08 Stone flies	0.10 Stone flies	0.44 Stone flies	1.42 0.90[2]
5	Below Spray 1 mile	0.22 May flies	1.06 May flies	0.70 May flies	0.08 May flies	0.06 Stone flies	0.18 Stone flies	2.30 2.08[2]
6	Below Spray 1 1/8 mile	1.62 May flies	0.57 May flies	0.50 May flies	0.06 May flies	0.26 Stone flies & flies	0.54 Stone flies & Caddis flies	3.55 1.93[2]
7	Below Spray 1 1/2 mile	1.13 May flies	0.87 May flies	0.69 May flies	0.33 May flies & Stone flies	0.24 Stone flies	0.40 Stone flies	3.66 2.53[2]

[1] Station 1 was planned to be the control but was sprayed. Station 0 was established after spraying as a check.

[2] Total after spray.

Table 8 - Summary of mortality of insects and fish in live cars Canyon and Trapper Creeks

Sprayed 7/2/56 (4-6 a.m.)				
Stream section	Live car (fish & insect)	Spray (average lbs. per acre)	Mortality of insects 24 hrs. after spraying (percent) 7/3/56	Mortality of fish 5 days after spraying 7/6/56
		CANYON CREEK		
1	1	0	0	0
2	2	0.01	90	0
3	3	0.32	66	0
4	4	0.32	66	0
5	5	0.32	66	0
6	6	0.32	50	0
	7	0.32	0 1/	0
	8	0	0	0
		TRAPPER CREEK		
1	1	0.19	33	0
2	2	0.19	20	0
3	3	0.19	20	0
4	4	0	0 2/	0
5	5	0.10	10	0
6	6	0	0	0
	7	0	0	0
	8	0		0

1/ All insects were caddis flies which pupated.

2/ No mortality, but insects seemed to be affected

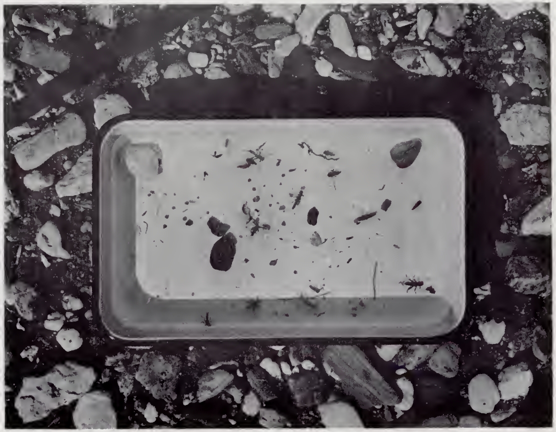


Figure 9. Contents of a square-foot bottom sample. Stone flies and may flies--Canyon Creek.

Drift Samples

A Leptodora towing net of zero mesh was used to make drift samples of stream insects as shown in figures 10 and 11. It was found that by leaving the net in the water five minutes an adequate sample could be obtained. All drift samples were taken at one location on each stream throughout the season, except as indicated in tables 9 and 10. The 5-minute sample of 1.5 cc. taken on July 1 before spray day in Canyon Creek (table 9) was predominantly early instar may fly nymphs. A similar sample on Trapper Creek of 0.2 cc. was composed of very small may fly and stone fly numphs. Under normal conditions these small nymphs are continually being carried downstream in the water. The samples taken on July 1 before spray day, and those following until July 9, indicate differences in volume of bottom fauna in the two streams. Canyon Creek is a richer trout food producing stream than Trapper Creek. This difference is also borne out in the bottom sample summaries (tables 6 and 7).

All of the insects taken in the net from 6:30 a. m. July 2 (spray day) to July 6 were dead and dying insects affected by the spray. A few minutes after the spray hit the water it began to affect the bottom organisms even though the oil floated on top, indicating that some DDT reached the bottom. On spray day the first drift sample on Canyon Creek was taken one hour after the spray hit the water (6:30 a. m.). This 5-minute sample contained 150 cc. of dead and dying insects, predominantly immature stone flies and may flies, and caddis flies. By 6:45 p. m. the volume had decreased to 55 cc. and by morning on July 3 it had decreased to 1.5 cc. No dead or affected nymphs of aquatic insects were taken in the net five days after spraying (July 6). The effect on Trapper Creek was similar except that the quantity of nymphs was less, due to a lower population of aquatic bottom fauna (tables 6 and 7).

The last samples taken on Canyon Creek in September and October show an increase in the volume of aquatic insects being carried down the stream. This indication of recovery in the population of bottom organisms is substantiated by the increase in volume of aquatic insects in the bottom samples shown in tables 6 and 7. This same increase does not show up in the Trapper Creek drift samples but data for both streams agree on the negligible amount coming downstream during the period July 9 to July 27 and also on the temporary increase the latter part of July and forepart of August. The lack of increase in the September and October samples on Trapper Creek could be significant. It could be partially due to the lower aquatic insect population but it might also be due to the fact that a greater portion of the headwaters of Trapper Creek was sprayed. This would leave fewer adult aquatic insects for egg laying to replenish lower depleted sprayed sections of the stream.

Drift samples taken above the spray area on both streams on July 2 and July 4 (tables 9 and 10) were prespray samples of small live aquatic insects. The samples taken on July 18 in Canyon Creek, both inside and outside of the spray area, indicate that there are times when very limited numbers of small nymphs are being carried downstream. This may be expected because the number being carried by the water is dependent upon hatching periods. On October 19 the sample at the cabin on Canyon Creek, which is within the spray area, contained 0.2 cc. (perhaps newly hatched) and the next day at the upper station outside the spray area it had 2.9 cc. On October 23 the samples taken at both stations were more nearly equal, but one was predominantly may flies and the other stone flies.

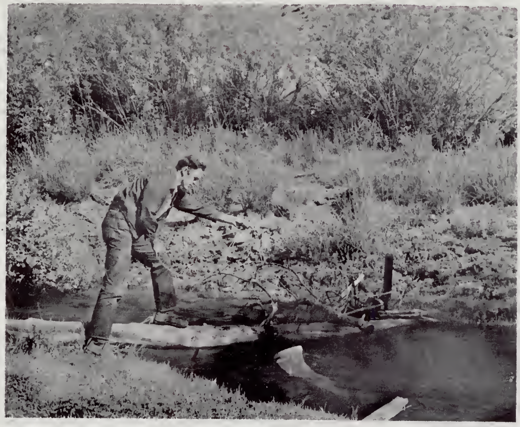


Figure 10. Placing plankton net in Trapper Creek.

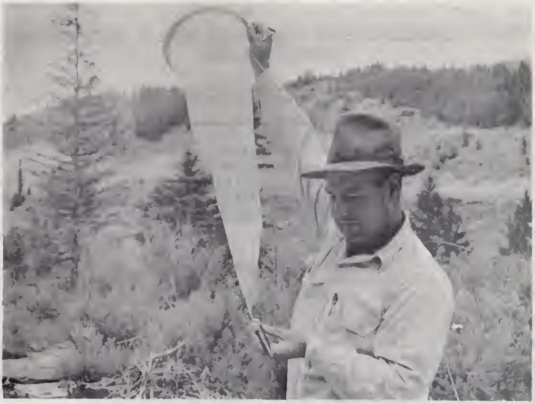


Figure 11. Plankton net with contents from 5-minute drift sample--Canyon Creek.

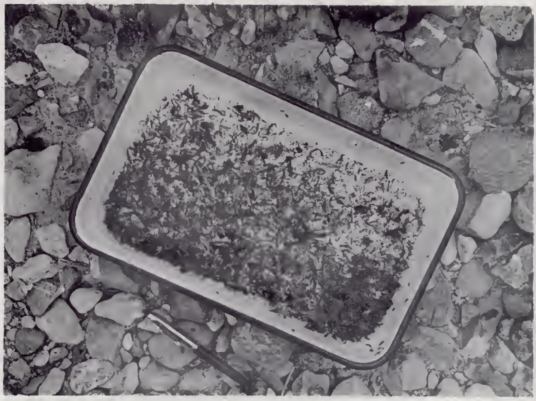


Figure 12. Contents of 5-minute drift sample on Canyon Creek several days after spraying.

Table 9 - Volumes of insects collected in 5-minute drift samples, Canyon Creek, 1956

Date	Volume (cc.)	Predominant forms	Remarks
7/1	1.5	May flies	Pre-spray
7/2 6:30 am	150.0	Stone flies, may flies, caddis flies	Spray day
7/2 7:30 am	110.0	Stone flies, may flies, caddis flies	Spray day
7/2 10:45 am	65.0	Stone flies, may flies, caddis flies	Spray day
7/2 2:45 pm	50.0	Stone flies, may flies, caddis flies	Spray day
7/2 6:45 pm	55.0	Stone flies, may flies, caddis flies	Spray day
7/2 10:00 am	1.5	Miscellaneous	Control station
7/2	1.5	May flies	
7/4 7:00 am	2.1	May flies and caddis flies	
7/4 5:00 pm	1.3	May flies	
7/5 7:00 am	1.3	May flies	
7/5 5:00 pm	0.3	Ants	
7/6	1.2	May flies	
7/9	0.1	May flies	
7/10	Trace	Stone flies	
7/11	Trace	Caddis flies and beetles	
7/12		Broken	
7/13	Trace	Miscellaneous	
7/16	Trace	Beetles	
7/17	Trace	Beetles	
7/18	Trace	Stone flies	
7/18	Trace	1 stone fly	Control station
7/19	Trace	3 beetles	
7/20	Trace	1 beetle	
7/23	Trace	5 beetles, 12 flies	
7/24	Trace	Beetles and flies	
7/25	Trace	Beetles and flies	
7/27	0.2	Flies	
7/30	0.4	Flies	
8/1	Trace	Flies	
8/3	0.4	Flies	
8/6	0.2	Flies	
8/8	0.1	Flies	
8/10	0.1	Flies	
8/13	Trace	Flies	
8/15	Trace	Flies	
8/17	Trace	Flies	
8/20	0.2	Flies	
8/22	Trace	Flies	
8/24	Trace	Flies	
8/27	Trace	Flies	
9/19	0.1	May flies and stone flies	
10/19	0.2	Stone flies	
10/20	2.9	May flies	Control station
10/23	0.15	May flies	Control station
10/23	0.1	Stone flies	

All samples taken at "Cabin station" except those marked "Control station."

Table 10 - Volumes of insects collected in 5-minute drift samples, Trapper Creek, 1956

Date	Volume (cc.)	Predominant forms	Remarks
7/1	0.2	Stone flies, may flies	Pre-spray
7/2 7:15 am	21.5	Stone flies, may flies, caddis flies	Spray day
7/2 10:15 am	12.0	Stone flies, may flies, caddis flies	Spray day
7/2 2:50 pm	8.2	Stone flies, may flies, caddis flies	Spray day
7/2 6:15 pm	7.5	May flies and caddis flies	Spray day
7/3	1.1	May flies and caddis flies	
7/4	1.3	May flies and flies	Control station
7/4 9:00 am	0.7	Stone flies and caddis flies	
7/5	0.2	Caddis flies	
7/6	0.1	Caddis flies	
7/9	Trace	Caddis flies	
7/11	Trace	Caddis flies	
7/12	Trace	Caddis flies and beetles	
7/13	Trace	Beetles and caddis flies	
7/16	Trace	Beetles	
7/17	Trace	Beetles	
7/18	Trace	Beetles	
7/19	Trace	Beetles	
7/20	Trace	Beetles and flies	
7/25	Trace	Beetles	
7/27	0.1	Beetles	
7/30	Trace	Beetles and flies	
8/1	0.2	Flies	
8/3	Trace	Flies	
8/6	Trace	Flies	
8/8	Trace	Flies and stone flies	
8/10	Trace	Flies	
8/13	Trace	Flies	
8/15	Trace	Flies	
8/17	Trace	Flies	
8/20	Trace	Water mites	
8/24	Trace	Water mites	
8/27	Trace	Flies	
9/21	Trace	Flies	
10/19	Trace	Flies	

All samples taken at "Upper ranch" station except the one marked "Control station."

Sweep-Net Collections

A standard insect net was used to collect aerial insects near the streambanks before spraying and at intervals during the season after spraying at 16 stations on the two streams. These stations, with two exceptions, were near the bottom sample stations (maps 1 and 2). Five sweeps of the net were made for each sample and twenty samples were taken at each station. The twenty net samples were taken from bushes on both sides of the stream adjacent to the bottom sampling areas. Only adults of aquatic bottom insects were tallied. See tables 11, 12, 13, and 14. Very few terrestrial insects were taken because the method of taking samples from bushes on the edge of the stream excluded them.

The reduction in adult aquatic insects appears to have been more drastic on Canyon Creek than on Trapper Creek. Effect on adults was, however, very definite on both streams. Midges (Tendipedidae) increased greatly, beginning with the second samples after spraying. This is a much faster buildup in population than is shown by bottom samples or drift samples. The lack of correlation between samples of aquatic adults and bottom samples may be due to the gelatinous covering of the eggs of flies which may protect them from the DDT spray. A good percentage of the flies occurring in the later bottom samples were midge larvae but the midges in the earlier aerial samples may have belonged to a different subfamily or genus. The figures shown for the samples of adult aquatic insects are based on numbers; bottom sample figures are given in volume. This accounts for some of the difference, since some dipterous larvae were found in bottom samples throughout the season but midges were too small to account for much volume. In numbers in some of the sprayed sections they were the predominant insects on the stream bottom after spraying, indicating a very short life cycle, protection from the DDT in the egg or early larval stage, or migration from unsprayed areas.

Table 11 - Numbers of adult aquatic insects collected by sweep net at Canyon Creek, 1956

Station	Spray (lbs. per acre)	6/25 to 6/27 Before spray	7/3 to 7/5 After spray	7/26 After spray	8/23 After spray	Total numbers
1	0	83 midges & caddis flies	76 midges	118 midges	53 midges	330 247 1/
7	0	76 midges & beetles	65 midges	116 midges	70 midges	327 251 1/
8	0	15 beetles & stone flies	11 beetles	130 midges	91 midges	247 232 1/
2	0.01	45 midges & stone flies	0	95 midges & caddis flies	63 midges	203 158 1/
3	0.32	95 stone flies	0	67 midges	51 midges	213 118 1/
4	0.32	46 stone flies midges & beetles	1 midge	15 midges	67 midges	129 83 1/
5	0.32	43 midges & stone flies	3 midges	37 midges	46 midges	129 86 1/
6	0.32	63 midges & stone flies	1 midge	47 midges	75 midges	186 123 1/
	TOTALS	466	157	625	516	

1/ After spray

Table 12 - Numbers of adult aquatic insects collected by sweep net at Trapper Creek, 1956

Station	Spray (lbs. per acre)	6/26 to 6/29 Before spray	7/3 to 7/4 After spray	7/31 After spray	8/23 After spray	Total numbers
1	0.19	57 midges & stone flies	20 midges	45 midges	127 midges	249 192 1/
8	0.19	97 stone flies	12 stone flies	49 midges	118 midges	276 179 1/
2	0.19	66 midges & stone flies	8 midges & stone flies	29 midges	79 midges	182 116 1/
3	0.19	63 midges & stone flies	5 midges & stone flies	19 midges & beetles	57 midges	144 81 1/
4	0	80 midges & stone flies	31 midges	22 midges & beetles	63 midges	196 116 1/
5	0.10	116 midges & stone flies	14 stone flies midges & beetles	53 midges	123 midges	306 190 1/
6	0	52 midges & stone flies	13 midges	40 midges	49 midges	154 102 1/
7	0	107 midges & stone flies	20 midges & stone flies	40 midges	103 midges	270 163 1/
	Total	638	123	297	719	

1/ After spray

Table 13 - Numbers of adult aquatic insects collected by sweep net at Canyon Creek, 1956

Date	Station	Spray (lbs. per acre)	Flies		Stone flies		Beetles		Caddis flies		Total Number
			No.	%	No.	%	No.	%	No.	%	
					BEFORE SPRAY						
6/25	1		40	48.0	9	10.9	14	17.0	20	24.0	83
6/27	7		31	40.8	18	23.7	27	35.5			76
6/27	8		2	13.3	3	20.0	8	53.2	2	13.3	15
6/27	2		18	40.0	20	44.4	6	13.3	1	2.2	45
6/27	3		18	21.2	56	65.9	11	13.0			85
6/27	4		14	30.2	17	37.0	14	30.2	1	2.2	46
6/27	5		15	34.5	21	48.8	7	16.3			43
6/27	6		42	66.5	16	25.3	5	7.9			63
					AFTER SPRAY						
7/3	6	0.32	1	100							1
7/4	5	0.32	3	100							3
7/4	4	0.32	1	100							1
7/4	3	0.32									0
7/5	2	0.01									0
7/5	8	0	2	18.0	1	9.0	8	73.0			11
7/5	7	0	46	70.0	9	14.6.	10	15.4			65
7/5	1	0	58	76.0	5	7.0	13	17.0			76
7/26	1	0	105	89.0	6	5.1			7	5.9	118
7/26	7	0	109	94.0	1	0.9	4	3.5	2	1.73	116
7/26	8	0	110	84.5	4	3.1	11	8.4	5	3.8	130
7/26	2	0.01	58	61.0			1	1.0	36	38.0	95
7/26	3	0.32	59	88.0					8	12.0	67
7/26	4	0.32	15	100							15
7/26	5	0.32	35	94.5					2	5.5	37
7/26	6	0.32	47	100							47
8/23	1	0	50	94.0			3	6.0			53
8/23	7	0	67	96.0			3	4.0			70
8/23	8	0	89	97.5			2	2.5			91
8/23	2	0.01	62	98.5			1	1.5			63
8/23	3	0.32	51	100							51
8/23	4	0.32	66	98.5			1	1.5			67
8/23	5	0.32	45	98.0			1	2.0			46
8/23	6	0.32	74	98.5			1	1.5			75

Table 14 - Numbers of adult aquatic insects collected by sweep net at Trapper Creek, 1956

Date	Station	Spray (lbs. per acre)	Flies		Stone flies		Beetles		Caddis flies		Total Number
			No.	%	No.	%	No.	%	No.	%	
					BEFORE SPRAY						
6/26	6		39	75.0	10	19.0	1	1.9	2	3.8	52
6/27	3		43	68.0	17	27.0	3	5.0			63
6/27	4		41	51.0	20	25.0	18	22.5	1	1.5	80
6/27	5		74	64.0	35	30.0	7	6.0			116
6/27	7		78	73.0	28	26.0	1	0.9			107
6/29	1		27	47.2	27	47.2	3	5.2			57
6/29	8		21	21.6	69	71.0	6	6.2	1	1.1	97
6/29	2		26	39.0	33	50.0	7	10.0			66
					AFTER SPRAY						
7/3	6	0	9	69.2	1	7.7	1	7.7	2	15.4	13
7/3	7	0	12	60.0	5	25.0	3	15.0			20
7/4	1	0.19	22	78.6	2	7.1	4	14.3			28
7/4	8	0.19	2	17.0	10	83.0					12
7/4	2	0.19	4	50.0	3	37.5	1	12.5			8
7/4	3	0.19	3	60.0	2	40.0					5
7/4	4	0	25	80.6	3	9.6	2	6.6	1	3.2	31
7/4	5	0.10	7	50.0	3	21.5	3	21.5	1	7.2	14
7/31	1	0.19	45	100.0							45
7/31	8	0.19	49	100.0							49
7/31	2	0.19	29	100.0							29
7/31	3	0.19	17	89.5			2	10.5			19
7/31	4	0.10	15	68.0			7	32.0			22
7/31	5	0	49	96.0			2	4.0			51
7/31	6	0	35	89.7			4	10.3			39
7/31	7	0	38	95.0			2	5.0			40
8/23	1	0.19	127	100.0							127
8/23	8	0.19	118	100.0							118
8/23	2	0.19	78	98.7	1 may fly						79
8/23	3	0.19	57	100.0							57
8/23	4	0.10	60	95.0	1	1.5	2	3.0			63
8/23	5	0	123	100.0							123
8/23	6	0	48	97.5			1	2.5			49
8/23	7	0	102	99.0			1	1.0			103

Trout Stomach Food Analysis

Trout stomach samples were taken at intervals during the season in spray areas to determine diets. The trout were always able to obtain ample amounts of food from terrestrial insects or fly larvae.

Samples were also taken of stomachs of fish held in the live cars. Table 15 shows the results of the analysis of these samples. As previously mentioned, stomachs from some of the trout held in the live cars were empty, and brook trout fed better under these abnormal conditions than did the rainbow trout. Quantities of aquatic insects killed by the spray were available to the fish in all of the live cars within spray areas. Live car number 1, located at the control station on Canyon Creek, contained an abundance of live larvae; again, the brook trout were the best feeders under these conditions.

Following the period when dead aquatic insects were plentiful, it was expected that within the sprayed areas where the bottom organisms had been depleted, trout would be hungry and easily caught. Actually there was no time during the season when fish could be caught easily in either stream.

There is no indication from the data collected during the 1956 season that trout were directly affected by the spray. Results, however, cannot be considered conclusive until additional data are collected in 1957.

Table 15 - Summary of the volumes of food in trout stomachs from Canyon and Trapper Creeks and from live cars held in these streams, 1956

Sample No.	Location	Date	Vol. (fish in cc.)	Spray (lbs. per acre)	Trout			Predominant Forms
					No.	Size (inches)	Species of fish1/	
		STOMACHS FROM FISH TAKEN FROM STREAMS						
1	Canyon Cr.	6/28	3.85	0	8	6 to 11	CT, EB, RB	Caddis fly, stone fly nymphs (pre-spray)
118	Station 3 Trapper Cr.	7/4	2.64	0.19	5	4 to 5	EB	Caddis fly and may fly nymphs
119	Station 2 Trapper Cr.	7/4	5.00	0.19	7 11 1	6 7 5	EB EB EB	Stone fly and may fly nymphs
210	Station 3 Trapper Cr.	7/11	0.90	0.19	1	10	EB	Ants and aerial forms
328	Station 6 Canyon Cr.	8/1	0.55	0.32	1 3	9 6 to 8	RB EB	Ants and aerial forms
329 330	Station 3 Canyon Cr.	8/2	7.00	0.32	1 1	12 8	RB EB	Fly larvae
342	Station 3 Canyon Cr.	8/2	1.00	0.32	1	8	EB	Ants
345	Station 4 Trapper Cr.	8/16	0.15	0.10	2	7	EB	Flies and aerial forms
346	Station 3 Canyon Cr.	8/17	2.00	0.32	2	7	EB	Ants and aerial forms
350	Station 2 Trapper Cr.	8/17	0.25	0.19	2	6	CT	Ants and fly larvae
351	Station 2 Trapper Cr.	8/17	0.20	0.19	10	6 to 8	EB	Aerial forms
401	Station 3 Canyon Cr.	8/21	1.26	0.32	4 5	8 7 to 8½	EB CT	May fly nymphs
		STOMACHS FROM FISH HELD IN LIVE CARS						
127	Cage 1 Trapper Cr.	7/6	0.40	0.19	1	5	EB	Stone fly and may fly nymphs
128	Cage 2 Trapper Cr.	7/6	1.80	0.19	1	5	EB	May fly nymphs
129	Cage 4 Trapper Cr.	7/6	2.60	0	1	4	EB	May fly nymphs
130	Cage 5 Trapper Cr.	7/6	0.30	0.10	1	4	EB	Caddis fly nymphs
131	Cages 6 & 7	7/6	1.70	0	2	4	EB	Caddis fly nymphs
132	Cage 8 Trapper Cr.	7/6	0.40	0	1	4	EB	Caddis fly and stone fly nymphs
133	Cage 4 Canyon Cr.	7/6	3.90	0.32	1	7	EB	May fly nymphs
134	Cage 1 Canyon Cr.	7/6	0.90	0.32	1	7	EB	Caddis fly nymphs
137	Cage 8 Canyon Cr.	7/6	2.50	0	1	7	EB	Stone fly nymphs

1/ CT - cutthroat trout
EB - eastern brook trout
RB - rainbow trout

Analysis of DDT in Water

Five water samples of one gallon each were taken at the lower edge of the spray area on Canyon Creek for the purpose of determining the amount of DDT in the water after spraying and after a heavy rain. Separate samples for the determination of turbidity were taken on both streams (table 16). The water in both streams was very clear, having only 0.09 parts per million of suspended material in the Canyon Creek sample and 1.0 parts per million in the Trapper Creek sample.

The first water sample taken immediately after spraying contained 0.10 parts per million of DDT. There was 0.33 parts per million of DDT one-half hour after spraying; 27 hours later the amount of DDT reached zero. It is quite probable that the 0.33 parts per million was near the peak of the amount of DDT at the point where the samples were taken.

The oil used as a diluent could be seen in the eddies along both streams for several days after spraying, and yet there was apparently no DDT in the water 27 hours after spraying. Information is needed on the action that takes place when the DDT strikes the water. The mortality and morbidity in bottom organisms suggest that DDT drops to the bottom quickly. The water samples indicate that DDT is freed from the water in less than 27 hours. The effect on the insects in the live cars indicates that the DDT is diluted as it moves downstream.

After a 1.2 inches rain no DDT was found in the water; the rain apparently did not cause leaching of DDT into the stream. The precipitation fell within a 12-hour period and the water sample was taken one hour after the rain stopped. This collection was near the peak of the increased streamflow due to this heavy rain.

Table 16 - DDT content and turbidity of water from Canyon Creek and Trapper Creek, 1956

ID no.[1]	Sample time		Location	DDT (p.p.m.)	Turbidity (p.p.m.)	Remarks
	Date	Hour				
30464	7/2	Time of spraying	Canyon Creek Bridge [2]	0.10	0.09	
30465	7/2	½ hrs. after spraying	Canyon Creek Bridge [2]	0.33		
30467	7/3	27 hrs. after spraying	Canyon Creek Bridge [2]	0		
30468	7/3	36 hrs. after spraying	Canyon Creek Bridge [2]	0		Taken 1 hr. after 1.2 inches of rain
-	7/2		Trapper Creek at smelter		1.0	

[1] Chemical analyses made by the Entomology Research Branch, Agriculture Research Service, U. S. Department of Agriculture.

[2] The samples on Canyon Creek were taken at aquatic insect bottom station 6 or live car station 5 where average amount of DDT reaching the water was 0.32 pound per acre.

Analysis of Inorganic Substances in Water and Flow Records

Streamflow and velocity were measured with a stream-depth and velocity gauge. Flow (cfs) and velocity (fs) were obtained for each station on the two streams as shown in tables 17 and 18. Flow and velocity decreased as the season advanced. Water for irrigation was diverted above the lower station on both streams. This loss was reflected in the readings at these stations when water was being used. The peak flow for both streams in June was three to four times as great as the late August flow.

The pH values were determined by using a calorimetric comparator. Readings shown on tables 19 and 20 for the two streams show that the hydrogen-ion concentrations are within the range favorable for fish and aquatic insects.

The methyl orange alkalinity was determined by using standard methods. (Figure 13.)

Daily maximum and minimum water temperatures were obtained by using a thermograph. One thermograph was located at the guard cabin on Canyon Creek and the other at the upper ranch house on Trapper Creek (maps 1 and 2). Table 21 shows the daily readings recorded. Average daily temperature fluctuation was 4 degrees for Trapper Creek and 9 degrees for Canyon Creek. According to the character and cover of the two streams, it would be expected that Trapper Creek would have the greater daily fluctuation. The reason for this difference between the two streams is not apparent from data collected.

Standard rain gauges were located at the guard cabin on Canyon Creek and at the upper ranch on Trapper Creek. These gauges were installed to measure rainfall from heavy storms. It was planned that water samples would be taken in the streams after storms to determine the amount of DDT leaching into the streams. The only heavy rainfall after spraying came on July 3, when 1.2 inches of rain fell. Results of the analysis of the water samples for DDT are shown in table 16.

Table 17 - Physical and Chemical Characteristics of Canyon Creek, 1956

Date	Hour	Station No.	Water depth (inches)	Water temperature (degrees F.)	Flow in cfs.	Velocity in f.s.	Turbidity	pH	M. O. alkalinity p.p.m.	Nature of bottom	Vegetation
6/22	3:30 pm	1	6 to 7	50	42	3-5	Clear	8.3	52	Gravel rubble	None
6/23	10:00 am	7	3 to 12	45	40	3-4	Clear	8.3	54	Gravel rubble	None
6/23	11:30 am	8	6 to 12	45	42	3-4	Clear	8.3	60	Gravel rubble	None
6/23	8:15 am	2	6 to 12	43	50	3-5	Clear	8.3	66	Gravel rubble	None
6/18	10:00 am	3	6 to 8	43	80	3	Clear	8.1	60	Gravel rubble	None
6/19	8:30 am	4	3 to 12	44	70.5	3-3	Clear	8.1	60	Gravel rubble	None
6/19	2:00 pm	5	6 to 8	53	57.5	3-4	Clear	8.1	60	Gravel rubble	None
6/19	3:30 pm	6	6 to 10	53	60	5	Clear	8.1	60	Gravel rubble	None
--	--	9	--	--	--	--	--	--	--	--	--
7/9	4:30 pm	1	6 to 12	58	39	3-4	Clear	8.1	62	Gravel rubble	None
7/10	9:00 am	7	3 to 10	50	39	3-4	Clear	8.1	62	Gravel rubble	None
7/10	10:00 am	8	3 to 8	50	28.2	2-4	Clear	8.2	68	Gravel rubble	None
7/10	11:00 am	2	3 to 10	53	28	3-4	Clear	8.2	68	Gravel rubble	None
7/9	10:30 am	3	6 to 10	50	36	3-4	Clear	8.4	86	Gravel rubble	None
7/11	9:00 am	4	4 to 12	50	31	2-4	Clear	8.3	76	Gravel rubble	None
7/10	4:00 pm	5	3 to 10	57	27	3-5	Clear	8.3	78	Gravel rubble	None
7/10	2:30 pm	6	6 to 10	56	27.5	2-8	Clear	8.4	88	Gravel rubble	None
--	--	9	--	--	--	--	--	--	--	--	--
7/23	9:00 am	1	3 to 8	51	25.5	2-3	Clear	8.3	70	Gravel rubble	Light algae
7/23	10:00 am	7	3 to 8	51	25	2-3	Clear	8.5	70	Gravel rubble	Light algae
7/23	11:00 am	8	3 to 10	54	25	2-4	Clear	8.5	80	Gravel rubble	Light algae
7/23	3:00 pm	2	3 to 8	61	18.74	2-4	Clear	8.5	79	Gravel rubble	Light algae
7/23	4:00 pm	3	3 to 8	60	16.7	2-4	Clear	8.6	88	Gravel rubble	Light algae
7/24	9:00 am	4	4 to 10	52	23	2-5	Clear	8.5	93	Gravel rubble	Light algae
7/24	10:00 am	5	3 to 10	53	23	3-4	Clear	8.5	95	Gravel rubble	Light algae
7/24	11:00 am	6	3 to 8	52	10.5	2-4	Clear	8.6	104	Gravel rubble	Heavy algae
8/6	4:00 pm	9	3 to 6	58		2	Clear	8.6	--	Gravel rubble	Algae
8/20	9:00 am	1	2 to 6	46	11	1-3	Clear	8.3	96	Gravel rubble	None
8/20	10:00 am	7	3 to 8	47	11	1-3	Clear	8.3	96	Gravel rubble	None
8/20	11:00am	8	5 to 10	48	12.7	2-3	Clear	8.3	100	Gravel rubble	None
8/20	1;00 pm	2	4 to 10	51	11.5	2-3	Clear	8.3	104	Gravel rubble	None
8/20	2:00 pm	3	3 to 8	52	11.5	2-3	Clear	8.4	106	Gravel rubble	None
8/20	3:00 pm	4	4 to 10	52	6	1-3	Clear	8.4	108	Gravel rubble	None
8/21	8:00 am	5	3 to 6	45	5.6	2-3	Clear	8.4	110	Gravel rubble	None
8/21	9:00 am	6	3 to 6	46	5.8	2-3	Clear	8.4	124	Gravel rubble	None
8/21	10:00 am	9	3 to 5	48	6	2	Clear	8.4	130	Gravel rubble	None

Table 18 - Physical and Chemical Characteristics of Trapper Creek, 1956

Date	Hour	Station No.	Water depth (inches)	Water temperature (degrees F.)	Flow in cfs.	Velocity in f.s.	Turbidity	pH	M.O. alkalinity p.p.m.	Nature of bottom	Vegetation
--	--	0	--	--	--	--	--	--	--	--	--
6/22	9:00 am	1	6 to 12	39	37	3-5	Clear	8.3	70	Gravel boulders	None
6/22	10:30 am	8	6 to 12	39	37	3-5	Clear	8.3	70	Gravel boulders	None
6/21	3:00 pm	2	8 to 12	43	34	3	Clear	8.3	75	Gravel rubble	None
6/21	11:30 am	3	6 to 10	44	34	3-5	Clear	8.3	75	Gravel rubble	None
6/20	2:30 pm	4	8 to 12	48	40	3-5	Slight	8.3	88	Gravel rubble	None
6/20	11:30 am	5	8 to 12	49	40	3-4	Clear	8.3	88	Gravel rubble	None
6/20	8:30 am	6	6 to 10	48	40	4	Clear	8.3	88	Gravel rubble	None
6/21	9:00 am	7	6 to 12	44	38	4-5	Clear	8.3	88	Gravel rubble	None
7/11	11:00 am	0	3 to 8	46	20	2-4	Clear	8.2	65	Gravel rubble	None
7/11	1:00 pm	1	3 to 10	52	20.5	2-5	Clear	8.2	70	Gravel rubble	None
7/11	2:00 pm	8	2 to 8	53	21	2-5	Clear	8.2	70	Gravel rubble	None
7/12	9:30 am	2	3 to 6	47	24	2-4	Clear	8.3	74	Gravel rubble	None
7/12	11:00 am	3	3 to 8	51	18	2-3	Clear	8.4	82	Gravel rubble	None
7/12	3:00 pm	4	4 to 8	56	22	3-5	Clear	8.3	98	Gravel rubble	None
7/12	4:00 pm	5	4 to 8	52	20	3-4	Clear	8.4	106	Gravel rubble	None
7/13	10:00 am	6	3 to 6	52	15.5	2-4	Clear	8.5	108	Gravel rubble	None
7/13	11:00 am	7	3 to 6	53	15	2-4	Clear	8.5	110	Gravel rubble	None
7/25	10:00 am	0	2 to 6	47	6	2-3	Clear	8.2	70	Gravel rubble	Light algae
7/25	11:00 am	1	3 to 8	51	9.7	2-4	Clear	8.2	76	Gravel rubble	Light algae
7/25	11:30 am	8	2 to 8	51	9.5	2-4	Clear	8.2	76	Gravel rubble	Light algae
7/25	12:30 pm	2	3 to 8	56	9	2-4	Clear	8.3	82	Gravel rubble	Light algae
7/25	1:00 pm	3	2 to 5	58	11.7	1-3	Clear	8.4	92	Gravel rubble	Algae
7/25	2:00 pm	4	3 to 8	58	7.7	2-4	Clear	8.4	114	Gravel rubble	Algae
7/24	3:30 pm	5	3 to 8	57	11.7	2-3	Clear	8.6	116	Gravel rubble	Algae
7/24	3:00 pm	6	3 to 8	59	9	2-4	Clear	9.0	118	Gravel rubble	Algae
7/24	2:00 pm	7	3 to 8	58	10	2-4	Clear	10.0	120	Gravel rubble	Heavy algae
8/22	9:00 am	0	4 to 6	43	--	2	Clear	8.3	90	Gravel	None
8/22	9:30 am	1	3 to 8	44	6.5	2-3	Clear	8.3	90	Gravel	None
8/22	10:00 am	8	4 to 8	45	6.4	2-3	Clear	8.4	90	Gravel	None
8/22	11:00 am	2	4 to 8	50	8.0	3	Clear	8.3	96	Gravel	None
8/22	12:00 am	3	2 to 6	52	7.2	2	Clear	8.4	108	Gravel	None
8/21	3:00 pm	4	4 to 10	55	10.7	3-4	Clear	8.3	134	Gravel	None
8/21	2:00 pm	5	4 to 10	56	11	2	Clear	8.4	142	Rubble	None
8/21	1:30 pm	6	4 to 8	59	4	2	Clear	8.4	140	Rubble	None
8/21	1:00 pm	7	3 to 6	58	4.75	3	Clear	8.5	134	Rubble	None

Table 19 - Summary of streamflow measurements and water chemistry determinations, Canyon Creek, 1956

Station	Date	Flow (cfs)	Velocity (f.s.)	pH	M.O. alkalinity (p.p.m.)
1	6/22	42	3 - 5	8.3	52
1	7/9	39	3 - 4	8.1	62
1	7/23	25.5	2 - 3	8.3	70
1	8/20	11	1 - 3	8.3	96
7	6/23	40	3 - 4	8.3	54
7	7/10	39	3 - 4	8.1	62
7	7/23	25	2 - 3	8.5	70
7	8/20	11	1 - 3	8.3	96
8	6/23	42	3 - 4	8.3	60
8	7/10	28.2	2 - 4	8.2	68
8	7/23	25	2 - 4	8.5	80
8	8/20	12.7	2 - 3	8.3	100
2	6/23	50	3 - 5	8.3	66
2	7/10	28	3 - 4	8.2	68
2	7/23	19	2 - 4	8.5	79
2	8/20	12	2 - 3	8.4	104
3	6/18	80	3 - 5	8.1	60
3	7/9	36	3 - 4	8.4	86
3	7/23	17	2 - 4	8.6	88
3	8/20	12	2 - 3	8.4	106
4	6/19	71	3 - 3	8.1	60
4	7/11	31	2 - 4	8.3	76
4	7/24	23	2 - 5	8.5	93
4	8/20	6	1 - 3	8.4	108
5	6/19	58	3 - 4	8.1	60
5	7/10	27	3 - 5	8.3	78
5	7/24	23	3 - 4	8.5	95
5	8/21	6	2 - 3	8.4	110
6	6/19	60	3 - 5	8.1	60
6	7/10	28	3 - 4	8.4	88
6	7/24	11	2 - 4	8.6	104
6	8/21	6	2 - 3	8.4	124

Stations in order from upper to lower portion of stream.

Table 20 - Summary of streamflow measurements and water chemistry determinations, Trapper Creek, 1956

Station	Date	Flow (cfs)	Velocity (f.s.)	pH	M.O. alkalinity (p.p.m.)
1	6/22	37	3 - 5	8.3	70
1	7/11	21	2 - 5	8.2	70
1	7/25	10	2 - 4	8.2	76
1	8/22	7	2 - 3	8.3	90
8	6/22	37	3 - 5	8.3	70
8	7/11	21	2 - 5	8.2	70
8	7/25	10	2 - 4	8.2	76
8	8/22	6	2 - 3	8.4	90
2	6/21	34	3 - 5	8.3	75
2	7/12	24	2 - 4	8.3	74
2	7/25	9	2 - 4	8.3	82
2	8/22	8	2 - 3	8.3	96
3	6/21		3 - 5	8.3	
3	7/12	18	2 - 3	8.4	82
3	7/25	12	1 - 3	8.4	92
3	8/22	7	1 - 2	8.4	108
4	6/20	40	3 - 5	8.3	88
4	7/12	22	3 - 5	8.3	98
4	7/25	8	2 - 4	8.4	114
4	8/21	11	3 - 4	8.3	134
5	6/20	40	3 - 4	8.3	40
5	7/12	20	3 - 4	8.4	106
5	7/24	12	2 - 3	8.6	116
5	8/21	11	2 - 3	8.4	142
6	6/20		3 - 4	8.3	88
6	7/13	16	2 - 4	8.5	108
6	7/24	9	2 - 4	8.6	118
6	8/21	4	2 - 4	8.4	140
7	6/21	38	4 - 5	8.3	88
7	7/13	15	2 - 4	8.5	110
7	7/24	10	2 - 4	8.6	120
7	8/21	5	2 - 3	8.5	134

Stations in order from upper to lower portion of stream.

Table 21 - Daily maximum and minimum water temperatures in degrees, Fahrenheit, Trapper and Canyon Creeks, 1956

Date	Trapper Cr.		Canyon Cr.	
	Max.	Min.	Max.	Min.
6/20	48	45		
6/21	49	45		
6/22	50	45		
6/23	50	48	51	47
6/24	50	46	51	43
6/25	50	45	53	41
6/26	52	45	56	43
6/27	54	48	56	44
6/28	55	49	57	46
6/29	54	49	56	45
6/30	51	47	54	42
7/1	51	48	52	43
7/2	49	44	49	42
7/3	49	44	51	41
7/4	49	45	50	41
7/5	50	46	53	41
7/6	51	48	56	45
7/7	53	48	57	44
7/8	53	48	55	43
7/9	55	50		
7/10	55	51		
7/11	54	51	59	50
7/12	54	49	59	47
7/13	53	50	55	49
7/14	54	49	52	47
7/15	53	50		
7/16	55	49	59	47
7/17	55	50	59	47
7/18	55	50	59	47
7/19	56	51	61	48
7/20	55	52	61	49
7/21	57	52	62	50
7/22	57	52		
7/23	56	52	63	50
7/24	56	53	58	50
7/25	58	53	65	51
7/26	57	52	60	49
7/27	55	53	59	52
7/28	56	52	60	49
7/29	57	53	61	51
7/30	55	52	63	49
7/31	54	52	56	51
8/1	53	49	56	48
8/2	54	51	55	48
8/3	54	50	55	45
8/4	53	50	51	44
8/5	52	49	55	44
8/6	52	50	54	49
8/7	52	49	52	45
8/8	54	48	53	42
8/9	53	50	55	47
8/10	51	49	54	46
8/11	52	49	53	45
8/12	53	48	50	45
8/13	50	49	56	46
8/14	54	50	56	47
8/15	54	52	57	50
8/16	57	51	56	48
8/17	56	51	55	47
8/18	55	50	55	44
8/19	54	49	52	46
8/20	54	50	51	46
8/21	54	49		
8/22	55	50	53	50
8/23	54	50	52	50
8/24	54	50	52	50
8/25	53	49	52	48
8/26	52	49	52	49
8/27	49	48		

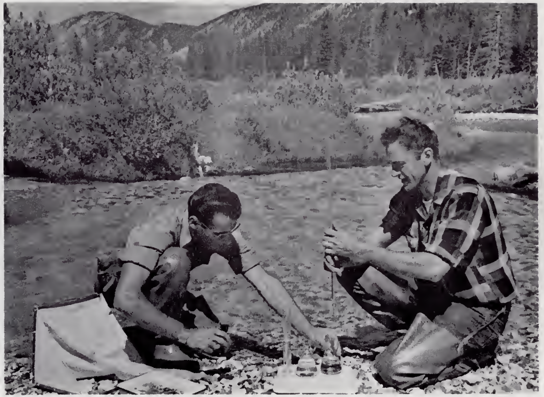


Figure 13. Testing water alkalinity--Canyon Creek.

EXTENSIVE STUDY STREAMS

Fish Shocking

The results of shocking for fish on the 11 streams on the extensive study are shown in tables 22, 23, and 24. The type of data collected on these streams was substantially the same as that for Canyon and Trapper Creeks. Population indices increased or remained about the same after spraying on all streams except on the Musselshell River at one Station. The reason for this difference is not apparent from the data collected. Trout condition decreased on some of the streams but the data do not show that this is related to the reduction of food brought about by the spray because decreases occurred on unsprayed sections as well as on sprayed sections. The condition of the trout in most of the sampling sections improved as the season advanced.

Bottom Samples

Table 25 shows the results of square-foot bottom samples taken on the 11 streams of the extensive study. It represents a total of 110 square feet of bottom samples. The data substantiate the findings on Canyon and Trapper Creeks. Aerial DDT spray caused a material loss of bottom organisms in sprayed sections but samples above and below spray areas show no substantial difference before or after.

Table 22 - Numbers of trout collected by shocking, Helena National Forest, 1956

Station no. and creek	Before Spray						After Spray						
	Date	Species of fish	No. of fish	Average			Spray (lbs. per acre)	Date	Species of fish	No. of fish	Average		
				Length (inches)	Weight (lbs.)	Condition factor					Length (inches)	Weight (lbs.)	Condition factor
1 - Prickley Pear	6/8	RB	31	6.3	0.10	33.4	5 miles below spray	7/10	RB	40	6.2	0.10	33.2
	6/8	EB	12	6.4	0.09	28.4		7/10	EB	20	6.0	0.07	31.6
Total			43							60			
2 - Prickley Pear	6/9	EB	23	6.1	0.09	34.7	below spray	7/24	EB	80	5.8	0.08	35.1
								7/24	RB	3	3.5	0.01	31.6
Total			23							83			
1 - Crow	6/28	RB	27	6.8	0.13	38.3	0.20	8/8	RB	34	6.7	0.14	36.2
	6/28	EB	5	5.9	0.09	39.3			EB	21	5.8	0.10	33.9
Total			32							55			
1 - McClellan	7/2	CT	14	5.2	0.07	47.3	Outside spray area	8/7	RB	16	5.0	0.06	34.1
2 - McClellan	7/3	RB	6	6.0	0.12	54.2		8/7	RB	6	5.3	0.06	32.9
		EB	4	6.2	0.13	57.7		8/7	EB	4	6.7	0.12	39.0
Total			10							10			
1 - Trout	6/12	RB	30	13.2	0.97	34.5	0.18	7/25	RB	16	8.8	0.33	41.1
		BT	13	9.8	0.54	40.5			BT	16	8.0	0.27	31.5
Total			43							32			
2 - Trout	6/13	BT	21	6.5	0.13	36.0	0.18	7/26	BT	19	6.7	0.15	37.4
1 - Beaver	6/14	BT	15	12.1	0.37	36.3	0.20	7/26	BT	21	8.9	0.36	37.9
		RB	15	5.7	0.11	32.4			RB	21	5.3	0.08	33.1
		EB	17	5.5	0.07	33.4			EB	9	6.2	0.11	38.9
									CT	8	7.5	0.21	37.3
Total			47							59			
2 - Beaver	6/14	RB	4	7.8	0.23	40.0	0.25	7/26	RB	5	6.8	0.13	34.6
		CT	2	7.8	0.19	38.3			CT	1	9.2	0.30	38.3
		EB	4	6.9	0.16	40.3			EB	4	7.0	0.14	35.7
		BT	1	7.8	0.18	38.1							
Total			11							10			

RB = rainbow trout
EB = eastern brook trout
CT = cutthroat trout
BT = brown trout

Table 23 - Numbers of Trout Collected by Shocking, Lewis & Clark National Forest, 1956

Station no. and stream	Before Spray						After Spray						
	Date	Species of fish	No. of fish	Average			Spray (lbs. per acre)	Date	Species of fish	No. of fish	Average		
				Length (inches)	Weight (lbs.)	Condition factor					Length (inches)	Weight (lbs.)	Condition factor
1 - Musselshell River	6/23	EB	123	5.4	0.06	33.8	0.43	7/31	EB	117	5.3	0.06	30.9
2 - Musselshell River	6/23	EB	230	4.8	0.04	34.1	0.43	7/31	EB	128	5.0	0.05	31.6
									RB	1	6.9	0.10	30.5
Total			353							246			
1 - Smith River	6/27	EB	59	5.4	0.07	38.2	0.20	8/1	EB	46	6.1	0.09	33.3
2 - Smith River	6/27	RB	12	6.1	0.11	41.7	0.20	8/1	RB	18	5.4	0.07	33.7
		EB	22	6.1	0.10	41.6			EB	12	6.1	0.10	35.6
									RB x CT	3	5.0	0.06	28.4
Total			34							33			
1 - Sheep Creek	6/22	RB	16	7.4	0.15	33.3	0.33	8/2	EB	11	5.8	0.06	28.8
		EB	14	5.4	0.05	29.8			RB	10	7.1	0.17	35.9
Total			30							21			
2 - Sheep Creek	6/22	RB	4	7.9	0.21	42.0	0.33		RB x CT	2	7.2	0.14	34.9
		CT	1	5.4	0.06	38.0							
		EB	17	5.4	0.07	37.5	0.33		EB	19	6.8	0.14	37.2
Total			22							21			
3 - Sheep Creek	6/25	EB	7	8.0	0.23	36.8	0.33	8/3	CT	4	6.7	0.11	32.1
		RB	19	6.6	0.15	39.4			RB	32	5.6	0.07	31.4
									RB x CT	7	7.3	0.17	30.7
Total			26							43			
4 - Sheep Creek	6/25	RB	29	6.8	0.13	34.5	0.33	8/3	RB	34	6.1	0.09	32.6
		EB	1	6.3	0.08	31.9			RB x CT	7	7.9	0.18	32.7
Total			30							41			
5 - Sheep Creek	6/27	RB	6	7.1	0.15	37.0	0.33	8/2	RB	8	6.7	0.15	38.2
		EB	24	5.5	0.07	35.1			EB	30	6.2	0.11	39.6
									RB x CT	6	8.3	0.27	41.8
Total			30							44			

RB = rainbow trout
EB = eastern brook trout
CT = cutthroat trout

Table 24 - Numbers of trout collected by shocking, Beaverhead National Forest (Trapper & Canyon Creeks not included), 1956

Station and creek	Before spray						After spray						
	Date	Species of fish	No. of fish	Average			Spray (lbs. per acre)	Date	Species of fish	No. of fish	Average		
				Length (inches)	Weight (lbs.)	Condition factor					Length (inches)	Weight (lbs.)	Condition factor
1 - Birch	6/19	None					above spray	7/18	None				
1 - Rock	6/18	EB	9	4.5	0.03	24.3	above spray	7/18	EB	18	5.2	0.05	34.2
1 - Rattlesnake	6/20	RB	5	6.1	0.09	33.5	5 miles below spray	7/20	RB	8	5.9	0.08	32.8
		EB	5	5.6	0.05	28.0			EB	3	4.6	0.03	27.8
Total			10							11			
2 - Rattlesnake	6/20	RB	7	6.0	0.08	32.7	5 miles below spray	7/23	RB	11	6.5	0.11	36.9
		EB	4	5.1	0.05	35.0			EB	6	5.8	0.09	35.8
Total			11							17			

EB = eastern brook trout
RB = rainbow trout

Table 25 - Volumes of invertebrates collected in bottom samples, Helena, Lewis & Clark, and Beaverhead National Forests (Trapper and Canyon Creeks not included), 1956

Stream	Forest	Before Spray			Spray	After Spray		
		Date	Volume (cc.)	Predominant form	(lbs. per acre)	Date	Volume (cc.)	Predominant form
Beaver Creek	Helena	6/13	3.2	Caddis flies	0.22	7/26	0.32	Earthworms, flies
Trout Creek	Helena	6/12	0.50	Caddis flies	0.18	7/25	0.04	Stone flies
Crow Creek	Helena	6/11	0.92	Caddis flies	0.20	8/8	0.02	Stone flies
McClellan Creek	Helena	7/4	0.94	Caddis flies	outside spray area	8/8	0.35	Stone flies
Prickly Pear Creek	Helena	6/8	0.56	Caddis flies	below spray	7/10	0.30	Caddis flies
North Fork of Musselshell River	Lewis & Clark	6/23	0.52	May flies	0.43	7/31	0.05	Earthworms, flies
Sheep Creek	Lewis & Clark	6/22	3.37	May flies	0.33	8/2	0.88	Flies
North Fork of Smith River	Lewis & Clark	6/27	1.54	Caddis flies	0.20	8/1	0.53	Caddis flies
Birch Creek	Beaverhead	6/19	0.05	May flies	above spray	7/19	0.16	Stone flies
Rock Creek	Beaverhead	6/18	0.17	May flies	above spray	7/18	0.14	Caddis flies
Rattlesnake Creek	Beaverhead	6/20	0.30	May flies	5 miles below spray	7/20	0.25	Caddis flies

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